Coherent EUV Scattering Microscopy

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We report the development of a coherent scattering microscopy (CSM) at 55 nm resolution employing coherent diffraction of EUV beam and phase-retrieval method. The phase-retrieval algorithm of hybrid input-output (HIO), which act like a lens in the optical microscopy, is used to form microscopic images. The lens-less imaging technique provides aberration-free diffraction-limited images without restriction on the resolution and depth-of-focus (DOF). Strictly speaking, in the scattering microscopy, the resolution is determined by the 2-D detector size, which limits a measurable angle of diffraction, i.e., numerical aperture (NA).

The CSM employing a wavelength of 13.5-nm EUV beam was installed at the BL3 beamline in the NewSUBARU synchrotron facilities. The resolution of the microscopy, which determined by the CCD chip size of 1" and the distance from sample to detector (~104 mm), is about 55 nm. In the experiment, the spatial and temporal coherence are made to meet the requirements for the image reconstruction by using a 5-um-diamter pinhole with 0.2-nm bandwidth EUV optics. Figure 1(a) shows a scanning electron microscopy (SEM) image of a 2-D periodic nanostructure on the EUV mirror. The diffraction pattern is obtained with an X-ray CCD of 2048 x 2048 pixels and the reconstructed image from the diffraction signals by using a hybrid input-output algorithm is shown in Fig. 1(b).

We believe that the successful demonstration of the reflective-type EUV scattering microscopy paves the way for a reliable EUV imaging system with higher throughput and lower cost of ownership. There features make it potentially an important inspection technique with a wide applications in both EUV lithography and biology.

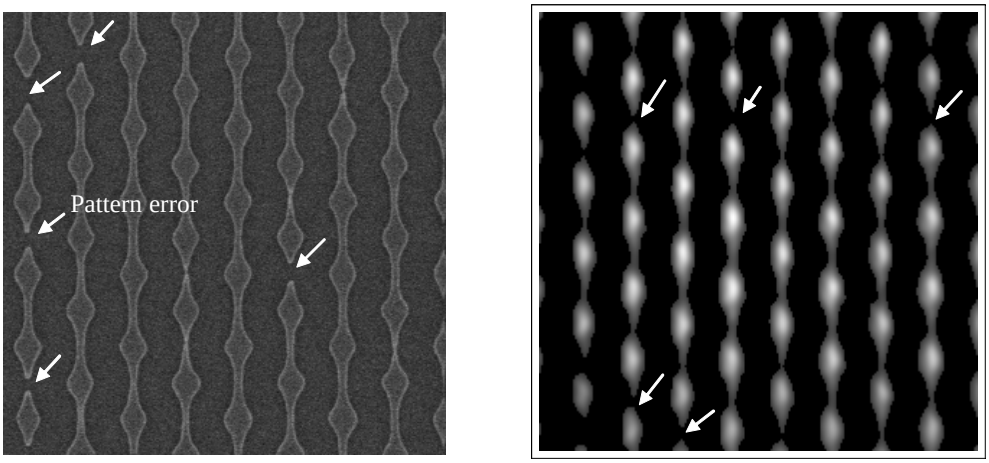

Fig. 1. (a) A SEM image of a 2-D periodic nanostructure on the EUV mirror with disconnected pattern errors (indicated by the white arrows) at the random positions. The maximum size and the pitch of the pattern in the x-direction are 107 nm and 224 nm, respectively. (b) Reconstructed image from a high-resolution diffraction pattern (a 2048 x 2048 pixel array) recorded from the sample (a).